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Neurocognitive Components of Word Processing: Evidence from Factor Analysis and Voxelwise Lesion Mapping

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Introduction

To identify core cognitive components of word processing and their neuroanatomical substrates, we factor analyzed a web-based database of scores from a word processing battery (Moss Aphasia Psycholinguistics Project Database; Mirman et al., 2010) and mapped the lesion correlates of the resulting factor scores.

Method

Ninety-nine individuals with diverse and wide-ranging post-stroke aphasia completed a battery of tests chosen to tap semantic and phonological processes in comprehension, production, and short-term memory. Factor analysis (FA) was carried out with the principal() routine in R, using 17 measures, with the oblimin rotation applied to the factor loadings. Factor scores were then used as dependent variables in voxel-based lesion-symptom mapping (VLSM) analyses.

Results

A model with 4 factors was naturally interpretable within the semantic-phonological framework. Factor 1 loaded primarily on measures of verbal and nonverbal semantic comprehension. Factor 2 loaded on phonological output processing (e.g., phonemic paraphasias in naming), while factor 3 loaded on phonological input processing (e.g., phonemic discrimination). Factor 4 loaded on lexical-semantic output processing (semantic errors in naming).

The VLSM of factor 1 (semantic comprehension) identified one voxel cluster in the lateral putamen extending into the anterior limb of the internal capsule and a second in the deeper portion of the MFG. Factors 2 (phonological output) and 3 (phonological input) both localized to the peri-Sylvian region (Figure 1). For factor 2, most of the significant voxels clustered above the Sylvian fissure, including a large concentration extending from the SMG anteriorly to premotor cortex. For factor 3, the significant voxels centered on the posterior planum temporale and extended into STG and, to a lesser degree, SMG. For factor 4 (lexical-semantic output), the first of two very large clusters extended from the mid-portion of the temporal lobe to the pole, while the second localized to prefrontal cortices.

Conclusion

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Factor analysis reduced many measures of the database to a small set of theoretically interpretable factors, featuring a primary semantic-phonologic distinction for input and output processing. The VLSM analyses of factor scores support and extend current knowledge. In particular, the results suggest that the peri-Sylvian representation of phonology (e.g., Henry et al., 2012) may be further specialized along input-output lines.

References

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Mirman, D., Strauss, T. J., Brecher, A., Walker, G. M., Sobel, P., Dell, G. S., & Schwartz, M. F. (2010). A large, searchable, web-based database of aphasic performance on picture naming and other tests of cognitive function. *Cognitive Neuropsychology*, 27, 495–504.

Figure Legend:

Figure 1. Voxels exceeding the FDR-corrected threshold ($q = .02$) in the VLSM of factor 2 (phonological output) ($t \geq 3.02$) are mapped in grey, those of factor 3 (phonological input) ($t \geq 3.32$) in black. A-C show axial, coronal and sagittal slices at MNI $X = -53$, $Y = -38$ and $Z = 17$, respectively.

